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(54) **ULTRASONIC SOUND EMITTING DEVICES FOR WIND TURBINES**

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(51) **Int. Cl.**

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F03D 11/00	(2006.01)
G10K 5/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A01M 29/18*** (2013.01); ***F03D 11/00*** (2013.01); *G10K 5/00* (2013.01); *Y02E 10/722* (2013.01)

(58) **Field of Classification Search**

CPC Y02E 10/74; Y02E 10/721; A01M 29/00; A01M 29/16; A01M 29/18; G10K 5/00

USPC .... 119/719, 713, 908; 416/1, 31, 61; 340/573.2, 384.2; 43/1, 98; 116/137 A

See application file for complete search history.

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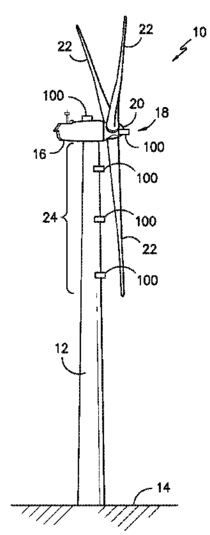
(57) **ABSTRACT**

A wind turbine may include a tower, a nacelle mounted on the tower and a rotor coupled to the nacelle. The rotor may include a hub and at least one rotor blade extending from the hub. In addition, the wind turbine may include a nozzle mounted on or within the tower, the nacelle or the hub. The nozzle may include an inlet and an outlet. Moreover, the nozzle may be configured to accelerate a flow of fluid through the outlet such that an ultrasonic sound emission is produced by the nozzle.

18 Claims, 4 Drawing Sheets



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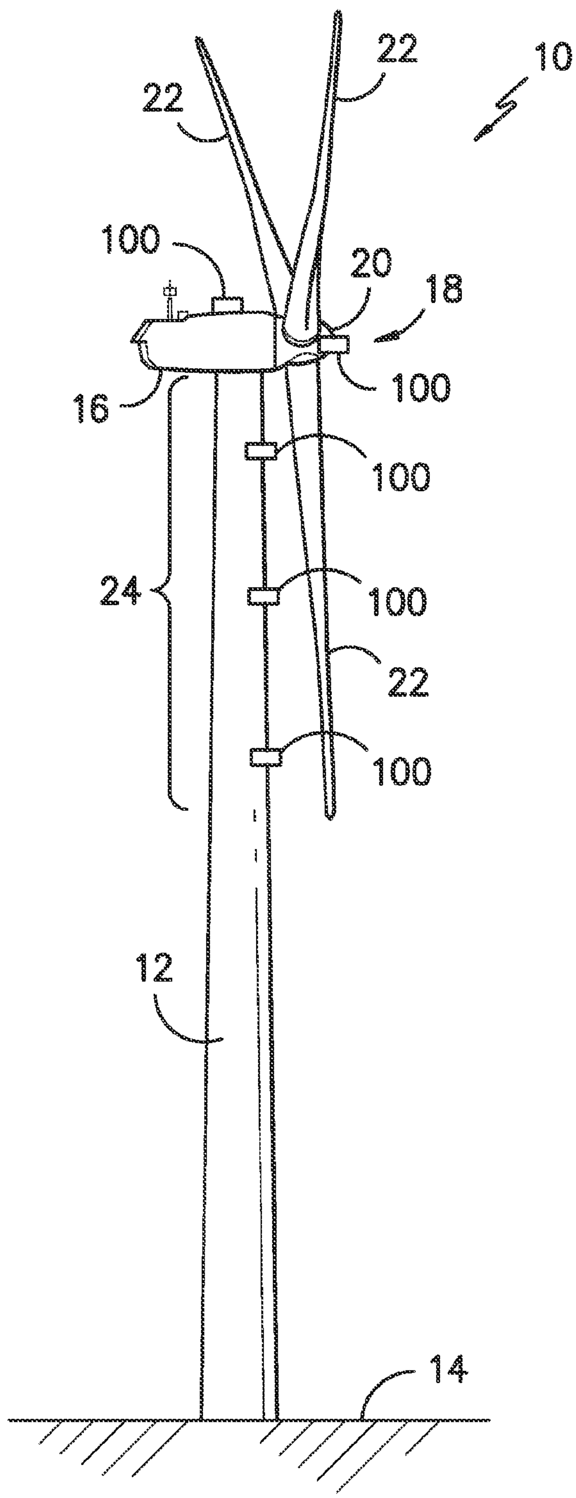

FIG. —1—

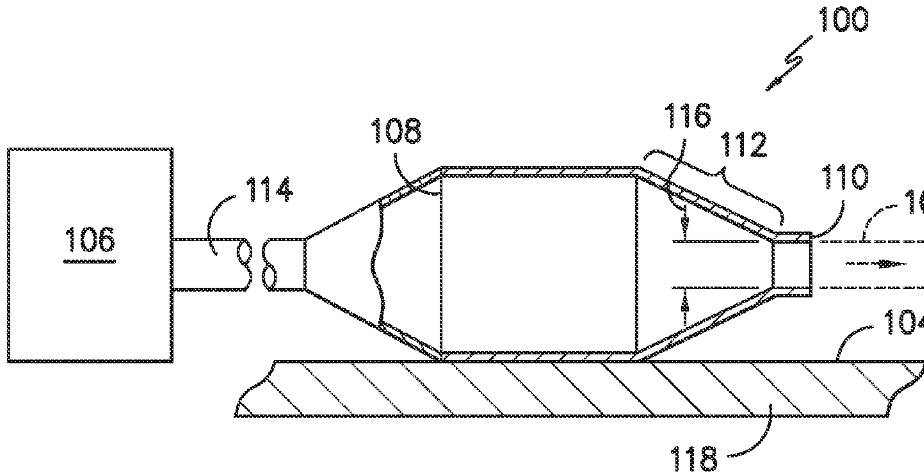
100
116
112
108
110
102
114
106
104
118

FIG. —2—

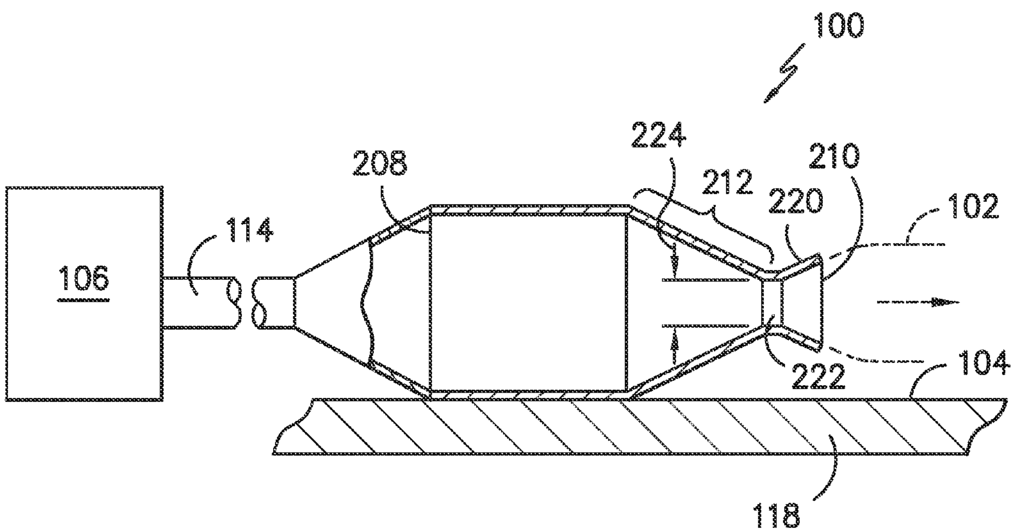
100
224
210
208
212
220
102
114
106
104
222
118

FIG. —3—

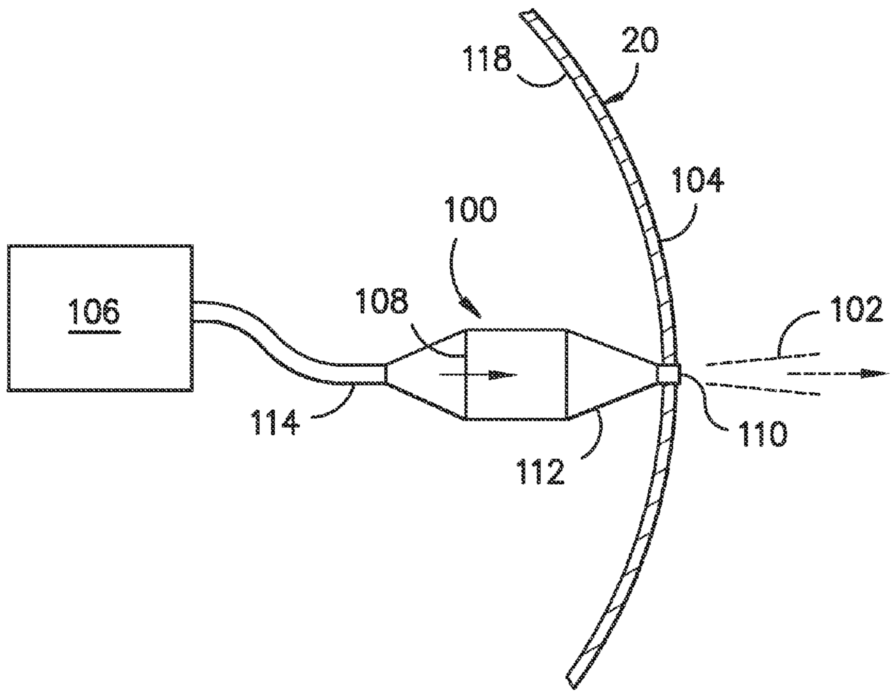
118
20
104
100
106
108
102
114
110
112

FIG. —4—

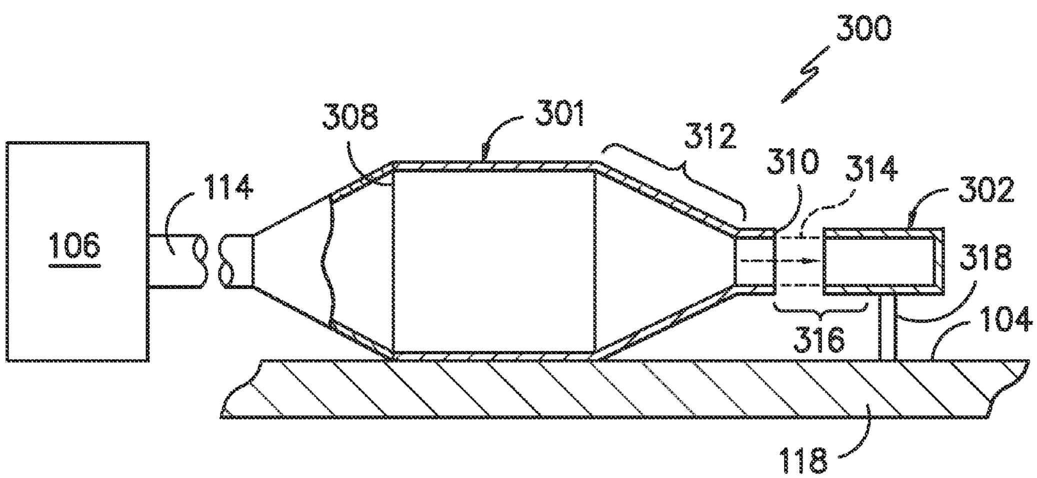
300
308
301
312
114
310
314
302
106
318
104
316
118

FIG. —5—

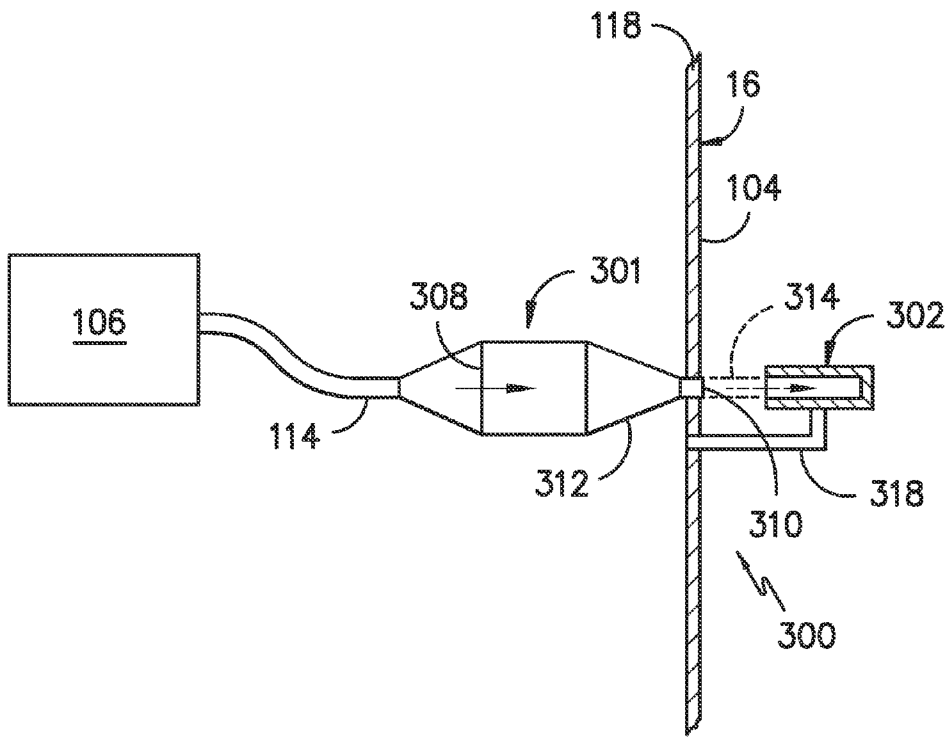

FIG. —6—

ULTRASONIC SOUND EMITTING DEVICES FOR WIND TURBINES

FIELD OF THE INVENTION

The present subject matter relates generally to wind turbines and, more particularly, to ultrasonic sound emitting devices that may be mounted on or within one or more components of a wind turbine to deter bats.

BACKGROUND OF THE INVENTION

Wind power is considered one of the cleanest, most environmentally friendly energy sources presently available, and wind turbines have gained increased attention in this regard. However, while being considered environmentally safe, wind turbines can pose a threat to bats. Specifically, it has been found that bats may have trouble detecting the rotating rotor blades of a wind turbine. As a result, bats can be struck by the rotor blades and killed. The occurrence of such bat strikes have led many to enact regulations and/or laws prohibiting and/or discouraging the placement of wind turbines in areas of high bat populations and/or restricting the operation of wind turbines at night.

Many believe that ultrasonic sound in the frequency range of about 25 kHz to about 100 kHz may be effective at deterring bats by interfering with both the bats' natural sonar and their ability to hunt insects. However, generating enough sound to cover the entire rotor diameter of a wind turbine has proven to be a difficult task. For example, previous attempts have focused on the use of speakers mounted on the nacelle. Unfortunately, due to dissipation of the sound, it has been found that nacelle mounted speakers do not provide for sufficient bat deterrence.

Accordingly, an ultrasonic sound emitting device that is capable of producing sufficient acoustic power to deter bats from a wind turbine would be welcomed in the technology.

BRIEF DESCRIPTION OF THE INVENTION

Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.

In one aspect, the present subject matter is directed to an active system for emitting ultrasonic sounds from a wind turbine. The system may include a nozzle configured to be mounted on or within a non-blade component of the wind turbine. The nozzle may include an inlet and an outlet. In addition, the system may include a pressurized fluid source in fluid communication with the inlet. The nozzle may be configured to accelerate a fluid flow derived from the pressurized fluid source through the outlet such that an ultrasonic sound emission is produced by the nozzle.

In another aspect, the present subject matter directed to a wind turbine including a tower, a nacelle mounted on the tower and a rotor coupled to the nacelle. The rotor may include a hub and at least one rotor blade extending from the hub. In addition, the wind turbine may include a nozzle mounted on or within the tower, the nacelle or the hub. The nozzle may include an inlet and an outlet. Moreover, the nozzle may be configured to accelerate a flow of fluid through the outlet such that an ultrasonic sound emission is produced by the nozzle.

In a further aspect, the present subject matter is directed to a method for producing an ultrasonic sound emission from a wind turbine. The method may generally include operating

the wind turbine with a nozzle mounted on or within a non-blade component of the wind turbine and supplying a fluid flow through an outlet of the nozzle such that an ultrasonic sound emission is produced by the nozzle.

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:

FIG. **1** illustrates a perspective view of one embodiment of a wind turbine having a plurality of ultrasonic sound emitting devices mounted on various non-blade components of the wind turbine;

FIG. **2** illustrates a cross-sectional view of one embodiment of an ultrasonic sound emitting device mounted to an exterior surface of a non-blade component of the wind turbine;

FIG. **3** illustrates a cross-sectional view of another embodiment of an ultrasonic sound emitting device mounted to an exterior surface of a non-blade component of the wind turbine;

FIG. **4** illustrates a partial, cross-sectional view of one embodiment of an ultrasonic sound emitting device mounted within a non-blade component of the wind turbine;

FIG. **5** illustrates a cross-sectional view of a further embodiment of an ultrasonic sound emitting device mounted to an exterior surface of a non-blade component of the wind turbine; and,

FIG. **6** illustrates a partial, cross-sectional view of another embodiment of an ultrasonic sound emitting device mounted within a non-blade component of the wind turbine.

DETAILED DESCRIPTION OF THE INVENTION

Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

In general, the present subject matter is directed to a wind turbine including one or more ultrasonic sound emitting devices configured to produce sound at a frequency within the ultrasonic range (e.g., from about 25 kHz to about 100 kHz). In several embodiments, the ultrasonic sound emitting devices may be one or more nozzles mounted on and/or within one or more non-blade components of the wind turbine, such as the nacelle, tower and/or hub of the wind turbine. A pressurized fluid source may be in fluid communication with each nozzle such that a fluid flow (e.g., an airflow) is directed into the nozzle and is choked, thereby producing a fluid jet (e.g., a supersonic air jet) at the nozzle outlet that emits sound within the ultrasonic frequency range. It is believed that the ultrasonic sound emitted from the disclosed nozzles may deter bats from flying into and/or adjacent to a wind turbine.

It should be appreciated that the disclosed nozzles may be configured to continuously generate an ultrasonic sound emission during operation of a wind turbine. However, due to the fact that the fluid source may be electronically controlled, fluid may, in several embodiments, only be supplied to nozzles during certain operating periods (e.g., during night-time operating hours) and/or the fluid may be pulsated through the nozzles such a pulsed or periodic ultrasonic sound emission is generated by the nozzles.

Referring now to the drawings, FIG. **1** illustrates a perspective view of one embodiment of a wind turbine **10**. As shown, the wind turbine **10** includes a tower **12** extending from a support surface **14**, a nacelle **16** mounted on the tower **12**, and a rotor **18** coupled to the nacelle **16**. The rotor **18** includes a rotatable hub **20** and at least one rotor blade **22** coupled to and extending outwardly from the hub **20**. For example, in the illustrated embodiment, the rotor **18** includes three rotor blades **22**. However, in an alternative embodiment, the rotor **18** may include more or less than three rotor blades **22**. Each rotor blade **22** may be spaced about the hub **20** to facilitate rotating the rotor **18** to enable kinetic energy to be transferred from the wind into usable mechanical energy, and subsequently, electrical energy. For instance, the hub **20** may be rotatably coupled to an electric generator (not shown) positioned within the nacelle **16** to permit electrical energy to be produced. It should be appreciated that, as used herein, the term "hub" may refer to the inner hub component (i.e., the component to which the rotor blades **22** are attached via the pitch bearings), the outer hub component (i.e., the component surrounding the inner hub—often referred to as the "spinner") or a combination of both the inner and outer hub components.

Additionally, in several embodiments, one or more ultrasonic sound emitting devices **100** may be mounted on and/or within one or more non-blade components of the wind turbine **10** to deter bats from flying into and/or adjacent to the wind turbine **10**. As used herein, the term "non-blade component" generally refers to any component of the wind turbine **10** not including the wind turbine's rotor blades **22**. Thus, non-blade components may include, but are not limited to, the tower **12**, the nacelle **16** and the hub **20** of the wind turbine **10**.

For example, as shown in FIG. **1**, one or more ultrasonic sound emitting devices **100** may be mounted on and/or within the tower **12**. It should be appreciated that, when mounting the ultrasonic sound emitting device(s) **100** on and/or within the tower **12**, it may be desirable, in one embodiment, to position the device(s) **100** along an upper portion **24** of the tower **12** (i.e., the portion of the tower **12** across which the rotor blades **22** pass during operation of the wind turbine **10**). However, in alternative embodiments, the ultrasonic sound emitting device(s) **100** may be mounted on/or within the tower **12** at any other suitable location along its length.

Moreover, one or more ultrasonic sound emitting devices **100** may also be mounted on and/or within the nacelle **16** at any suitable location. For example, as shown in FIG. **1**, in one embodiment, an ultrasonic sound emitting device **100** may be mounted at the top of the nacelle **16**. In another embodiment, one or more ultrasonic sound emitting devices **100** may be mounted on and/or within one of the sides of the nacelle **16**. Similarly, as shown in the illustrated embodiment, one or more ultrasonic sound emitting devices **100** may also be mounted on and/or within the hub **20** at any suitable location, such as at the front of the hub **20**.

It should be appreciated that the specific placement and number of the ultrasonic sound emitting devices **100** shown in FIG. **1** is simply provided as one example to illustrate how the disclosed devices **100** may be installed at different locations on and/or within the various non-blade components of the wind turbine **10**. Thus, one of ordinary skill in the art should appreciate that, in general, any number of devices **100** (including a single device **100**) may be positioned at any suitable location on and/or within the wind turbine **10** in order to deter bats from flying into and/or adjacent to the wind turbine **10**.

Referring now to FIG. **2**, a cross-sectional view of one embodiment of an ultrasonic sound emitting device **100** is illustrated in accordance with aspects of the present subject matter. As shown, in several embodiments, the ultrasonic sound emitting device **100** may comprise a converging nozzle **100** mounted to an exterior surface **102** of a non-blade component of the wind turbine **10**, such as the exterior surface **102** of the tower **12**, the nacelle **16** and/or the hub **20**. In general, the nozzle **100** may be configured to generate a fluid jet **102** (e.g., a supersonic air jet) as fluid flows through the nozzle **100**. Thus, as shown in FIG. **2**, the nozzle **100** may be in fluid communication with a suitable pressurized fluid source **106** such that a fluid flow may be directed through the nozzle **100**. As will be described below, by appropriately selecting certain dimensions of the nozzle **100**, the airflow through the nozzle **100** may be accelerated to the point of choking (i.e., at or above a speed of Mach 1), thereby producing a supersonic jet **102**. As the fluid jet **104** exits the nozzle **100**, a shock wave-expansion system (i.e., shock cells or a shock cell structure/pattern) is created such that, as the turbulence in the shear layers around the jet **102** interact with the shock cells, an ultrasonic sound emission may be generated within a frequency ranging from about 25 kHz to about 100 kHz.

As particularly shown in FIG. **2**, the nozzle **100** may generally include an inlet **108**, an outlet **110** and a converging section **112** extending between the inlet **108** and the outlet **110**. The inlet **108** may generally be configured to be in fluid communication with the pressurized fluid source **106** to allow a pressurized flow of fluid to be supplied through the nozzle **100**. For example, as shown in FIG. **2**, the inlet **108** may in fluid communication with the fluid source **106** via a hose or other suitable fluid conduit **114**. The converging section **112** may generally correspond to a portion of the nozzle **100** along which the cross-sectional area of the nozzle **100** steadily decreases between the inlet **108** and the outlet **110**, thereby causing the air entering the inlet **108** to be accelerated as its flows through the converging section **112**. Thus, by appropriately selecting the size of the outlet **110**, the fluid flow through the converging section **110** may be choked as it reaches the outlet **110**. As is generally understood, the cross-sectional area required to choke the fluid flow may generally vary depending on the total mass flow through the nozzle **100** and the total pressure of the flow. However, in several embodiments, the outlet **110** may have a diameter **116** ranging from about 1 millimeter (mm) to about 15 mm, such as from about 1 mm to about 5 mm or from about 5 mm to about 15 mm and all other subranges therebetween. However, it is foreseeable by the inventors of the present subject matter that the diameter **116** of the outlet **110** may be smaller and/or larger than then values contained within the ranges described above.

It should be appreciated that, in several embodiments, the diameter **116** of the outlet **110** may be selected so as to specifically tailor the frequency of the ultrasonic sound emission produced by the nozzle **100**. For instance, in one embodiment, an outlet diameter **116** ranging from about 5 mm to about 15 mm may be utilized to produce ultrasonic sound at a frequency of about 25 kHz while an outlet diameter **116** ranging from about 1 mm to about 5 mm may be utilized to produce ultrasonic sound at a frequency of about 100 kHz. Accordingly, it may be desirable to position multiple nozzles **100** having different outlet diameters **116** at various locations on the wind turbine **10** such that ultrasonic sound emissions at different frequencies may be produced.

It should be appreciated that the nozzle **100** may generally be configured to be mounted to the exterior surface **102** using any suitable fastening means and/or method known in the art. As used herein, a nozzle **100** may be mounted to the exterior surface **102** of a non-blade component by being directly or indirectly coupled to such surface **102**. Thus, in several embodiments, the nozzle **100** may be mounted to the tower **12**, nacelle **16** or hub **20** using one or more suitable fastening mechanisms (e.g., screws, bolts, pins, rivets, and/or the like) and/or by using one or more coupling devices (e.g., brackets, frames, support members and/or the like).

Moreover, it should be appreciated that the pressurized fluid source **106** may generally comprise any suitable device, container and/or the like that allows for a pressurized fluid (e.g., pressurized air) to be supplied to the nozzle **100**. For example, in one embodiment, the pressurized fluid source **106** may comprise an air compressor or any suitable vessel containing pressurized fluid. In addition, when the wind turbine **10** includes multiple nozzles **100**, each nozzle **100** may be in fluid communication with a single fluid source **106** or multiple fluid sources **106** may be utilized to supply pressurized fluid to the nozzles **100**.

Additionally, it should be appreciated that, in several embodiments, the pressurized fluid source **106** may be configured to supply fluid to the nozzle **100** at a constant pressure or at a variable pressure. For example, in a particular embodiment, the fluid source **106** may be configured to module the pressure of the fluid supplied to the nozzle **100** in order to modulate the frequency of the ultrasonic sound emission produced by the nozzle **100**. Such modulation of the fluid pressure may, in several embodiments, be regulated via a controller or other suitable computing device commutatively coupled to the fluid source **106**, thereby allowing the frequency of the ultrasonic sound emission to be automatically increased or decreased as the pressure is adjusted.

It should also be appreciated that the pressurized fluid source **106** may generally be configured to be positioned at any suitable location relative to the nozzle **100**. For example, in one embodiment, the fluid source **106** may be configured to be mounted to the exterior surface **102** adjacent to the location of the nozzle **100**. In another embodiment, the fluid conduit **114** coupling the fluid source **106** to the nozzle **100** may extend through a wall **118** of the non-blade component (e.g., a wall **118** of the tower **12**, the nacelle **16** and/or the hub **20**) such that the fluid source **106** may be housed within the interior of such component. In other embodiments, the fluid source **106** may be disposed at any other suitable location relative to the nozzle **100**. For instance, the fluid source **106** may be located on the support surface **14** or ground adjacent to the wind turbine **10** and the fluid conduit **114** may be configured to extend between the nozzle **110** and the fluid source **106** along the interior of the wind turbine **10** (e.g., through the interior of the tower **12**, the nacelle **16** and/or the hub **20**) or along the exterior of the wind turbine **10**.

Additionally, it should be appreciated that, in alternative embodiments, the nozzle **100** need not be configured as a converging nozzle. For example, in one embodiment, the nozzle **100** may simply be configured as a thin walled tube or orifice defining a constant diameter between the outlet **108** and the inlet **110**.

Referring now to FIG. **3**, a cross-sectional view of another embodiment of the nozzle **100** shown in FIG. **2** is illustrated in accordance with aspects of the present subject matter. As shown, the nozzle **100** may be configured as a de Laval or any other suitable convergent-divergent nozzle. Thus, in addition to having an inlet **208**, an outlet **210** and a converging section **212**, the nozzle **100** may also include a diverging section **220** extending between the converging section **212** and the outlet **210**. In such an embodiment, a nozzle throat **222** may be located between the converging section **212** and the diverging section **220** and may define the point at which the cross-sectional area of the nozzle **100** transitions from decreasing (along the converging section **212**) to increasing (along the diverging section **220**).

By configuring the nozzle **100** in the manner shown in FIG. **3**, the fluid flow may, for example, be accelerated to a supersonic speed as it flows through the converging section **212** and into the nozzle throat **222**. Thus, similar to the outlet **110** described above, the size of the nozzle throat **222** may generally be selected based on the total mass flow through the nozzle **100** and the total pressure of the flow. For example, in several embodiments, the nozzle throat **222** may have a diameter **224** ranging from about 1 millimeter (mm) to about 15 mm, such as from about 1 mm to about 5 mm or from about 5 mm to about 15 mm and all other subranges therebetween. However, it is foreseeable by the inventors of the present subject matter that the diameter **224** of the nozzle throat **220** may be smaller and/or larger than the values contained within the ranges described above.

In addition, by configuring the nozzle **100** to include the diverging section **220**, the fluid jet **102** traveling through the nozzle throat **222** may expand as it flows through the diverging section **220**. Such expansion may generally allow the shape of fluid jet **102** to be modified as it exits through the outlet **210**, thereby altering the frequency of the ultrasonic sound emitted by the nozzle **100**. It should be appreciated that the diameter/cross-sectional area to which the nozzle **100** increases between the throat **222** and the outlet **210** may generally vary depending on the sound characteristics desired to be achieved, the dimensions of the nozzle throat **222** and/or various other parameters/conditions. However, in several embodiments, a ratio of the cross-sectional area of the outlet **210** to the cross-sectional area of the throat **222** may range from about 1:1 to about 1.2:1, such as from about 1.03:1 to about 1.1:1 or from about 1.1:1 to about 1.2:1 and all other subranges therebetween. However, it is foreseeable by inventors of the present subject matter that the ratio of the cross-sectional area of the outlet **210** to the cross-sectional area of the throat **222** may be smaller and/or larger than then values contained within the ranges described above.

It should be appreciated that, in addition to being mounted to an exterior surface **102** of one or more of the non-blade components of the wind turbine **10**, the nozzles **100** described above may also be at least partially mounted within such component(s). For example, FIG. **4** illustrates the nozzle **100** shown in FIG. **2** mounted partially within the interior of the front portion of the hub **20**. Specifically, as shown, the nozzle **100** may be mounted within the hub **20** such that the outlet **108** extends through a wall **118** of the hub **20** to its exterior surface **102**. As such, the fluid jet **102** generated within the nozzle **100** may be expelled to the exterior of the hub **20**, thereby ensuring that the ultrasonic sound emission generated as the jet **102** exits the nozzle **100** propagates outwardly from the hub **20**.

Alternatively, as indicated above, the nozzles **100** may be mounted within any other suitable non-blade component of the wind turbine **10**. For example, instead of being a wall **118** of the hub **20**, the wall **118***e* shown in FIG. **4** may correspond to a wall **118** of the tower **12** and/or a wall **118** of the nacelle **16**.

Referring now to FIG. **5**, a cross-sectional view of another embodiment of an ultrasonic sound emitting device **300** that may be mounted to an exterior surface **102** of one or more of the non-blade components of the wind turbine **10** is illustrated in accordance with aspects of the present subject matter. As shown, the ultrasonic sound emitting device **300** may be configured as a Hartmann generator or any other suitable powered resonance tube. Thus, the device **300** may include both a converging nozzle **301** and a closed-end tube **302** disposed downstream of the nozzle **301**.

In general, the nozzle **301** may be configured the same as or similar to the nozzle **100** described above with reference to FIG. **2**. For example, as shown in FIG. **5**, the nozzle **301** may include an inlet **308**, an outlet **310** and a converging section **312** extending between the inlet **308** and the outlet **310**. In addition, the nozzle **201** may in fluid communication with a suitable pressurized fluid source **106**. As described above, the nozzle **301** may generally be configured to generate a fluid jet **314** (e.g., a supersonic air jet) as fluid flows through the nozzle **301**.

Similar to various Hartmann generators and/or other powered resonance tubes known in the art, the closed-end tube **302** may generally be configured to have the same diameter and/or cross-sectional area as the nozzle outlet **310** and may be aligned with the outlet **310** such that the fluid jet **314** exiting the nozzle **301** is directed into the tube **302**. Thus, by positioning the tube **302** relative to the outlet **310** so that the tube **302** is disposed within a compression region **316** of the shock cell structure/pattern created at the outlet **310** as the jet **314** exits the nozzle **301**, a strong flow instability (including successive compression and expansion waves) may be created within the tube **302**. As a result of such flow instability, an ultrasonic sound emission may be generated by the ultrasonic sound emitting device **300** at a frequency ranging from about 25 kHz to about 100 kHz.

It should be appreciated that the closed-end tube **302** may generally be mounted in alignment with the nozzle outlet **310** using any suitable attachment means known in the art. For example, as shown in FIG. **5**, the tube **302** may be mounted to the exterior surface **102** using any suitable coupling **318** (e.g., a pin, bolt, rod and/or other suitable linkage) that permits the tube **302** to be positioned in alignment with the nozzle outlet **310**. Alternatively, the tube **302** may be held in alignment with the nozzle outlet **310** via a coupling or linkage extending between the tube **302** and the nozzle **301**.

Referring now to FIG. **6**, the ultrasonic sound emitting device **300** shown in FIG. **5** is illustrated in a configuration in which the nozzle **301** is partially mounted through a wall **118** of one of the non-blade components of the wind turbine **10**. Specifically, in the illustrated embodiment, the nozzle **301** is mounted within the nacelle **16** such that the outlet **310** extends through the wall **118** of the nacelle **16**. As such, the fluid jet **314** generated within the nozzle **301** may be expelled to the exterior of the nacelle **16**. Additionally, as shown, the closed-end tube **302** may be mounted outside the nacelle **16** (e.g., by using a suitable coupling **318**) such that the tube **302** is generally aligned with the nozzle outlet **310**. Thus, the fluid jet **314** generated by the nozzle **301** may be directed into the closed-end tube **302**, thereby producing an ultrasonic sound emission propagating outwardly from the nacelle **16**.

Alternatively, as indicated above, the nozzle **301** may be configured to be mounted within any other suitable non-blade component of the wind turbine **10**. For example, instead of being a wall **118** of the nacelle **16**, the wall **118** shown in FIG. **6** may correspond to a wall **118** of the tower **12** and/or a wall **118** of the hub **20**.

It should be appreciated that the present subject matter is also directed to an active system and method for producing an ultrasonic sound emission from a wind turbine **10**. In several embodiments, the system may generally include one or more of the disclosed nozzles **100**, **301** in fluid communication with one or more suitable fluid sources **106**. Additionally, in several embodiments, the method may generally include operating the wind turbine **10** with a nozzle **100**, **301** mounted on and/or within a non-blade component of the wind turbine **10** and supplying a fluid flow through the nozzle **100**, **301** such that an ultrasonic sound emission is produced.

Additionally, it should be appreciated that the ultrasonic sound emissions produced by the disclosed nozzles may generally travel from the nozzles in a cone-shaped sound path. Thus, it may be desirable to orient the nozzles on a wind turbine **10** such that the sound emissions are directed towards the locations at which bats are to be deterred. For example, in one embodiment, the nozzles installed on a particular wind turbine **10** may be oriented such that the sound emissions are directed toward the front of the wind turbine **10** (i.e., along the side of the nacelle **16** at which the rotor blades **22** are located).

It should also be appreciated that, although the present subject matter has been described herein as using nozzles to produce ultrasonic sound emissions, various other ultrasonic sound emitting devices may also be used to deter bats from a wind turbine **10**. For example, in one embodiment, a speaker capable of producing ultrasonic sound emissions may be mounted on and/or within one or more of the non-blade components of the wind turbine **10**. Alternatively, various other devices, such as a powered Helmholtz resonator, a dual bi-morph synthetic jet and/or the like, may be mounted on or within one or more of the non-blade components in order to produce ultrasonic sound emissions.

Moreover, although the present subject matter has been described primarily as using nozzles to produce a supersonic fluid jet, ultrasonic sound emissions may also be produced with sub-sonic fluid jets. Thus, it should be appreciated that the disclosed subject matter may generally be utilized to generate any suitable fluid jet that is capable of producing an ultrasonic sound emission.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. An active system for emitting ultrasonic sounds from a wind turbine, the system comprising:

a nozzle configured to be mounted on or within a non-blade component of the wind turbine, the nozzle including an inlet and an outlet; and

a pressurized fluid source in fluid communication with the inlet, wherein the nozzle is configured to accelerate a fluid flow derived from the pressurized fluid source through the outlet such that an ultrasonic sound emission is produced by the nozzle,

wherein the outlet extends through a wall of the non-blade component.

2. The system of claim **1**, wherein the non-blade component comprises one of a tower, a nacelle or a hub of the wind turbine.

3. The system of claim **1**, wherein the outlet has a diameter ranging from about 1 mm to about 15 mm.

4. The system of claim **1**, wherein the nozzle further comprises a converging section extending between the inlet and the outlet.

5. The system of claim **4**, wherein the nozzle further comprises a diverging section downstream of the converging section, a nozzle throat being defined between the converging and diverging sections.

6. The system of claim **1**, further comprising a closed-end tube disposed downstream of the nozzle such that the fluid exiting the outlet is directed into the closed-end tube.

7. A wind turbine, comprising:

a tower;

a nacelle mounted on the tower;

a rotor coupled to the nacelle, the rotor including a hub and at least one rotor blade extending from the hub; and,

a nozzle mounted on or within the tower, the nacelle or the hub, the nozzle including an inlet and an outlet,

wherein the nozzle is configured to accelerate a flow of fluid through the outlet such that an ultrasonic sound emission is produced by the nozzle.

8. The wind turbine of claim **7**, wherein the nozzle is mounted to an exterior surface of the tower, the nacelle or the hub.

9. The wind turbine of claim **7**, wherein the outlet has a diameter ranging from about 1 mm to about 15 mm.

10. The wind turbine of claim **7**, wherein the nozzle further comprises a converging section extending between the inlet and the outlet.

11. The wind turbine of claim **10**, wherein the nozzle further comprises a diverging section downstream of the converging section, a nozzle throat being defined between the converging and diverging sections.

12. The wind turbine of claim **7**, wherein the outlet extends through a wall of the tower, the nacelle or the hub.

13. The wind turbine of claim **7**, further comprising a pressurized fluid source in fluid communication with the inlet.

14. The wind turbine of claim **7**, further comprising a closed-end tube disposed downstream of the nozzle such that the fluid exiting the outlet is directed into the closed-end tube.

15. The wind turbine of claim **7**, wherein the nozzle is mounted on or within the tower.

16. The wind turbine of claim **7**, wherein the nozzle is mounted on or within the nacelle.

17. The wind turbine of claim **7**, wherein the nozzle is mounted on or within the hub.

18. A method for producing an ultrasonic sound emission from a wind turbine, the method comprising:

operating the wind turbine with a nozzle mounted on or within a non-blade component of the wind turbine; and

supplying a fluid flow through an outlet of the nozzle such that an ultrasonic sound emission is produced by the nozzle.

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